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Procedia Engineering 87 (2014) 160 – 163
Procedia Engineering
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EUROSENSORS 2014, the XXVIII edition of the conference series

# High Carbon-High porous SiOC glasses for room temperature $NO_2$ sensing

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**Abstract**

Porous SiOC is proposed as suitable material for gas sensing applications, exploiting its high surface area and high carbon content. The typical high electrical resistance of SiOC, which prevented till now its exploitation to develop conductometric devices, is solved through a proper control of its carbon content and thermal treatments. The developed gas sensors showed high sensitivity to $NO_2$ at room temperature and up to 400°C. We believe that this new kind of nanoporous ceramic gas sensors can give a new perspective for application of ceramic materials in gas sensing field.

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*Keywords:* SiOC; RT gas sensing; NO2; porous ceramics; Carbon rich

## 1. Introduction

The common operating temperature for metal oxides to respond $NO_2$ is between 300-500°C [1-2]. However, in many cases, the high-temperature operation is not favorable, i.e. in an explosive environment [2]. In this study, we propose porous SiOC glasses, a ternary system of Si-O-C, as a $NO_2$ sensing material at low temperatures. SiOC is known for its high temperature stability but it has never been considered as sensing material due to its high resistivity. In this work we show that the proper control of its structure and stoichiometry allows obtaining resistance

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Peer-review under responsibility of the scientific committee of Eurosensors 2014
doi:10.1016/j.proeng.2014.11.608

values suited for gas sensing application. Indeed, the functional characterization of the prepared sensor devices demonstrates that porous SiOC is a possible candidate for room temperature $NO_2$ sensing.

## 2. Experimental

Porous SiOC ceramics starting from aerogels are prepared by a polymer derived method. In this simple process, highly porous ambigels are successfully employed as precursors to get porous SiOC with high surface area [3]. Final SiOC composition so as the resistivity of the final ceramic can be adjusted by changing starting gel (xerogels) composition and the pyrolysis temperature which gives great flexibility to change the sensitivity of the sensor. Responses are tested by *in situ* DC conductance measurements from RT to 500°C with 30% humidity.

## 3. Results and discussion

Porous SiOC ceramics are prepared, starting from aerogels, by a polymer pyrolysis method [3]. In this simple process, highly porous aerogels are successfully employed as precursors to get porous SiOC with specific surface area as high as 588 $m^2/g$. Final SiOC composition and accordingly the resistivity of the final ceramic- is adjusted by changing the starting aerogel composition and the pyrolysis temperature which gives great flexibility to change the sensitivity of the sensor. In this work, we increase the C content to increase the conductivity and to shift $NO_2$ response to room temperature compared to low carbon-low porosity SiOC glasses [4].

The gas sensing properties of SiOC are investigated from room temperature to 500°C. The material reveals high selectivity and good sensitivity towards $NO_2$ (5-10 ppm) with null response to $H_2$. The gas response to $NO_2$ at room temperature is quite remarkable. As the operating temperature increases, the response to $NO_2$ decreases and totally disappears at 400°C. Dynamic gas responses to $NO_2$ (5 ppm) at RT-250°C are plotted in Figure 1. Although response is the highest at room temperature, the recovery is irreversible at this temperature.

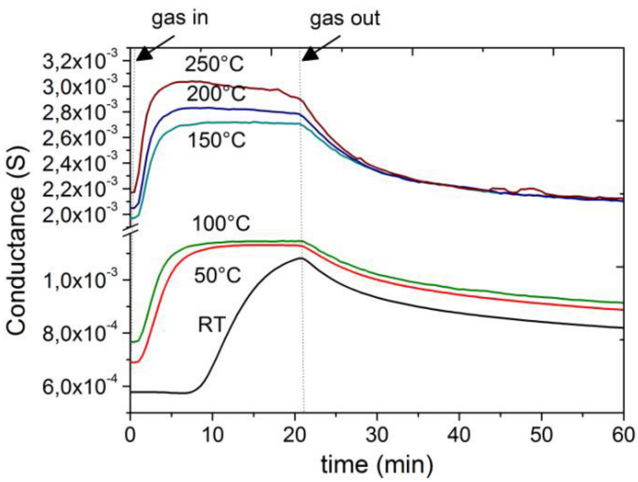


Fig. 1. Dynamic response exhibited by SiOC sensors to 5 ppm $NO_2$ from room temperature to 250°C

As temperature increases, the sample responds faster and recovery changes from irreversible to reversible. The response time, recovery time and response as a function of operation temperature is plotted in Figure 2-3. The sample starts giving response to $H_2$ after 400°C only when SiOC loses its sensitivity towards $NO_2$ (not shown).

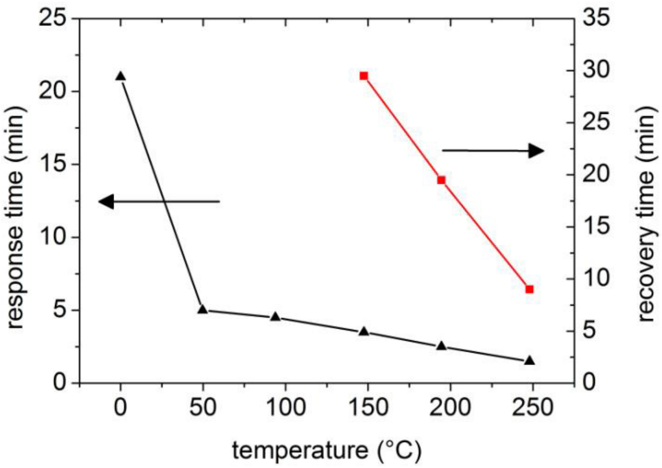


Fig. 2. Response and recovery time of the sample to 5 ppm $NO_2$ from room temperature to 250°C

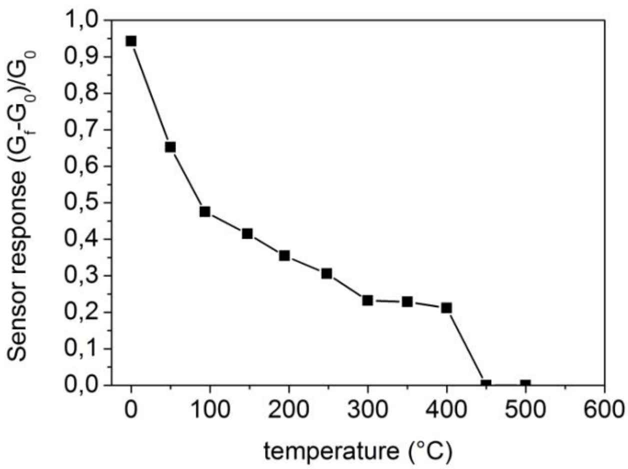


Fig. 3. $NO_2$ responses at RT-500°C

## 4. Conclusions

SiOC glasses show two distinct behaviors: T<400°C, they are very sensitive to $NO_2$ and T>400°C the $NO_2$ sensitivity disappears and they response to $H_2$. It is possible to tailor the sensing properties playing with Carbon content in the starting precursor. Increasing the porosity and carbon content in the structure resulted in high conductivity and NO2 response to shift to RT.

## Acknowledgements

A part of this work is supported by NAOMI project, Provincia Autonoma di Trento and Marie Curie Initial Training Network ''FUNEA'', MCITN-264873, EU.

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